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Co-Designing Prototypes for User Experience and Engagement in Automation *

Case Study of London-based Airport Future Workplace

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ABSTRACT. Here we present a case study to explore the implications of the co-design of future autonomous technologies for user experience (UX) and engagement. Given the high demand for automation in daily life and workplaces, there is a need to assess the value of co-design with the end-users to evaluate users' experiences and engagements in multiple contexts such as work, health, entertainment, and learning. The term automation in this paper also covers some of the so-called AI or more sophisticated automation. This case is driven by a member of the innovation department of the airport and UX researchers. Our main objective was to employ participatory design and work domain analysis (WDA) as a means for co-designing future automated systems for smart work in airport terminal operations. Over two weeks in two workshops in a London-based airport, we used participatory design and scenario-based design methods to explore how and where we should draw a line between end-user agency and automation to improve the work experience supported by automation in the future workplace. Users' experiences such as sense of control, welfare, and social sustainability were assessed. Our findings will be used for creating prototypes and demos for the airport of the future. We also came with a framework for designing prototypes and selecting new systems for redesigning the workplaces.

Keywords: HCI, Participatory Design, Automation, Personas, User Experience, Interaction Design, HWID

1 Introduction

Automation and the introduction of Industry 4.0 interactive technologies in industrial work systems have brought new ambiguities in the challenges and burdens on interactive systems designers [25]. The term automation in this paper also covers some of the so-called Artificial Intelligence (AI) or more sophisticated automation. Socio-Technical System Design (STSD) has identified and addressed several problems in understanding and developing complex autonomous systems [1, 4, 10, 13]. Despite many positive outcomes, these methods have not materially changed industrial software engineering practices [40]. Two of the main reasons behind this are not knowing the users well and involving them only in the testing stage of any new system development instead of the design process [3, 5]. The challenges of designing systems are increasing with changing demographics, which impact and pressure the limited resources to meet complex systems' needs. Therefore, service design and co-design processes are utilised to facilitate collaboration in new ways [34]. Human beings are the multiple stakeholders (i.e., customers, operators, decision-makers) who collaborate and interact with the different systems [38]. Designing future technologies needs more cross-organisational collaborations to produce innovative and creative outcomes.

Researchers have studied various user experience (UX) aspects to implement advanced interactive technologies employing automation in different platforms [1, 4, 13, 37]. These technologies support and improve end users' work but not necessarily and automatically guarantee a positive response from them in relation to aspects of their experience, such as a sense of control or transparency on machine decisions [1]. More studies on UX and innovation are needed in light of advances in AI and the growing use of more sophisticated automation technologies [13].

There is a significant value in developing and refining design guidelines for human-AI interaction [2, 28]. Simultaneously, there is a need for cooperation and better communication in human teams and individuals and AI systems to achieve better UX goals for future automation scenarios, namely AI/UX goals. Hence, future autonomous systems need to be carefully co-designed to achieve expected service quality goals for end-users. This is especially the case in safety and operationally critical work domains such as airports. Thus, understanding the relation between human work and interaction design is crucial and part of the agenda of the sub-field of Human-Work Interaction Design (HWID) [12]. Human Work Interaction Design (HWID) is a comprehensive framework that establishes relationships between extensive empirical work-domain studies and HCI designs. It builds on the foundation of Cognitive Work Analysis (CWA) [12]. HWID is currently positioned as a modern, lightweight version of CWA.

In this paper, we report on a case study that employs participatory design and work domain analysis (WDA) [8] as a means for co-designing future automated systems considering AI/UX goals in the context of airport terminal operations. HCI studies [28, 39, 42] suggest that using co-design can bring more success when some participant users are not professional developers. However, the latter's input towards designing interaction significantly impacts design and user engagement [36, 44, 45].

Despite disputes and differences between stakeholders' internal cultures or communication [43], a common understanding and a shared vision to develop a new design can be facilitated to an efficient outcome.

The presented case study is driven by a member of the innovation department of a London-based airport and two UX researchers. This paper describes the process of a team of UX researchers and operational decision-makers of an airport in co-designing two scenarios supporting smart work in the terminal. Recruitment of the participant was based on interest, role, and familiarity with the topic. Workshop sessions resulted in two future work scenarios leading to automated systems' prototyping using Abstraction Hierarchies for each scenario. The objective is to explore and illustrate how a London-based airport uses participatory design, interaction design, and WDA methods to decide future autonomous Industry 4.0 systems. The paper concludes with lessons we learned in three themes, operational environment, organisational environment, and co-designing workshop settings. These themes presented the findings clustered mainly in design approaches, social sustainability, and user sense of control.

2 Related work

2.1 The Smart Workplaces

'Smart Workplaces' is a vision where the organisation is fully connected with all stakeholders via proactive adaptation to the organisation's real-time needs, including operational necessities and customer requests. Besides many technical factors, national, cultural, geographic, social, and organisational factors will have an important role in designing optimal socio-technical systems as they impact users' interaction (i.e. both operators and employees) and the smart systems in their work and lives [1, 12]. For example, security concerns in airports necessitate more investigations prior to boarding, resulting in long queues and waiting times for passengers. Hence, airports need to be more innovative in their operations and stakeholders' handling (passengers and workers) and their real-time needs [27].

Industry 4.0 has enabled innovation in design and manufacturing [21] and led to more "smart workplaces" in industrial settings. There are, however, blurring gaps, challenges, and concerns in the design of industry 4.0 future technologies. Moreover, and specific to the case of airports, there are more challenges such as data privacy, immigration, and security, or reduced workforce employment, which impose legal and public policy pressures on implementing "Airport 4.0" [27, 28]. In a complex organisation employees are generally not considered in the design process nor satisfied with the new technologies and systems involved in the smart workplaces. Therefore, we will argue that using specific approaches similar to the co-design workshops we suggested for designing future smart workplaces can lead to positive work experiences. Specifically, such workshops with specific design tools or

templates can increase the human counterpart's (employees/end-user) engagement with the final product in the future smart workplace [31].

Industry4.0 means organisations should prepare for new forms of work, and novel interactions between humans and machines, which implies redesigning the job and the workplace for more cooperation between human and machine workers. In such workplaces, the shared tasks between the two counterparts are expected to be flexible and allocated fairly to ensure the human counterpart's well-being. Therefore, industrial tasks are expected to become more knowledge-intensive to change employees' roles [28]. Operators of the future may transition to makers who work alongside digitalised and automated production systems with essential creativity to solve unexpected and unforeseen challenges rather than assist or monitor non-discretionary workflow steps or processes [46].

New smart workplace systems change and directly impact the operational workers, their well-being, system performance, and the work's nature [25]. Due to AI implementation in such systems, there is also significant value in developing and refining design guidelines for human-AI interaction in future systems [2, 28]. There is a need for cooperation and better UX goals for human teams and individuals interacting with AI systems, namely AI/UX goals [2]. Hence, future autonomous systems need to be carefully co-designed to achieve expected service quality goals for end-users.

2.2 Participatory Design, Persona, and UX

Co-design, or participatory design, is a dominant design technique. Approaches that have emerged to promote user engagement in system development have been implemented in different industries, such as aviation [36, 44, 45]. The co-design approach has gained interest in developing commercial and business applications [11] as both a system development approach and philosophy; participatory design advocates the direct participation of stakeholders, especially users or their representatives. The participatory design process emphasises mutual learning, as none of the participants, either 'designer' or 'user' knows everything. Designers are expected to have technical knowledge on the issue, the process, and future users. This knowledge may be applied from an academic perspective to create new knowledge or an industrial point of view to innovate systems and product designs. Also, designers may include users who intimately know the domain and the use context, i.e. the activity and practices into which the new technology will be introduced [44]. Users in co-design approaches may often have a strong sense of ownership and commitment to the created software products [11]. A persona is a communicational tool typically used within User-Centered Design [35], which was introduced for mass-market software development. Personas in co-design projects have begun to include users and others in either persona inceptions or assemblies or its deployment. Personas in co-design are usually used as objects of conversation in design, validation of designs via designer-created personas, and user-created personas [28].

A study for future automation work in Finland shows that UX design needs to balance its brand and image and its values to its customer [28]. This study

nominated several AI/UX goals regarding the future automated systems: Sense of control, Trust in human-automation cooperation, Sense of freedom, Ownership of the process, Relatedness to the work community, Meaningfulness to the work community, and Success and achievement [28]. We embedded the same AI/UX goals in our study.

2.3 Human Work Interaction Design

HWID studies how to understand, conceptualise, and design for the complex and emergent contexts in which information and communication technologies (ICT) and work are entangled [12]. HWID models are based on the characteristics of humans and work domain contents and the interactions during their tasks and decision-making activities. HWID focuses on integrating work analysis (i.e. WDA methods) and interaction design methods (e.g. goal-oriented design and HCI usability) for smart workplaces. The ultimate goal of HWID is to empower users by designing smarter workplaces in various work domains.

Applying the HWID framework to specific workplaces considering several independent and entangled factors is essential [12]; numerous theories, concepts, techniques, and methods developed for other work environments. Environmental contexts such as national, cultural, geographic, social and organisational factors will have an important role in designing optimal HWID framework, as they impact the interaction between users and smart systems in their work and life. More work-related factors include the users' knowledge/skills, application domain, work contents and goals, and the nature of tasks or newly introduced technologies to be considered in the interaction performance. Developing the HWID framework requires establishing design goals, evaluation of usability and user experience, engagement of all stakeholders, and transparent design processes.

2.4 Work Domain Analysis and Abstraction Hierarchies

WDA is part of the broader CWA framework that supports and structures the analysis needed when designing a flexible and adaptive system [48]. WDA, as part of that framework, focuses on analysing the limitations and constraints of a work domain and workers' behaviour; and mapping these constraints in the design of the system that will support the workers. Using WDA has two distinct advantages. First, WDA is a multi-dimensional analysis that incorporates the physical and the social environment to provide a detailed description. Secondly, WDA can be paired with interface design [18] to generate new information system designs. WDA has shown success in the design of analytic information displays in power plant displays [9], social systems [19], healthcare decision support [8], community building [14], and smart universities [1].

Abstraction Hierarchy (AH): we decided to use the Abstraction Hierarchy (AH) from the Work Domain Analysis (WDA) design method toolset, as it is one of the

main analysis techniques providing a discreet and complete description of a work domain at different abstraction levels. Furthermore, AHs are suitable to use by stakeholders from different backgrounds with little or no experience of WDA [3, 6]. AH is a cognitive engineering approach to human-machine systems design supported by empirical studies of operators' fault-finding strategies. In this case study, AH developed concepts and methods for modeling the conceptual design of industrial automation systems [29].

AH describes a system, product, or experience at five levels of abstraction: (1) functional purpose, (2) abstract function, (3) generalised function, (4) physical functions, and (5) physical forms. The concepts and elements define the system's goal and purpose at the highest level (1–2), and the lowest levels of the model (3–5) describe the physical components of the system [41]. Using the model from top to bottom answers how the solution and experience are achieved, whereas moving from the bottom towards the top of the model reveals why particular elements or components of the solution and experience exist [8]. Despite its origins in the analysis of safety-critical domains, AHs are used as design tools for innovation in other domains that demand less rigor and regulation [22].

2.5 Future Scenario

Researchers predict future industries' development or services based on grounded foundations to answer whether technological developments in future workplaces are realistic or desirable for the wider public [23]. Decision-makers can use the resulted knowledge to avoid the negative consequences of using such future technologies [23]. 'Scenarios' are common tools used in many future studies [23, 28] with different approaches to increase creativity. It is popular to use simple stories based on trends and events to capture future possibilities. This can generate ideas by facilitating brainstorming sessions for more realistic scenarios or adopting 'blue sky thinking' to turn current trends and signals into the future experience [23].

Johnson introduced the Science Fiction Prototyping method as a practical guide for intelligent environment research. He believes that using fiction is a way to imagine our future in a whole new way [24]. One popular study [28] used science fiction prototyping as a practical design tool that works based on stories grounded in current science and engineering research to act as prototypes for people to explore a wide variety of futures.

3 Case Study questions and setting

Aviation is one of those sectors where brand, value, and organisational image have a significant role in their offerings. Customer and, more recently, worker satisfaction are among the main drivers for this sector to select more sustainable competitive advantages strategies and the latest technologies [52]. Our reported case study is not an exception to such practices. This study focused on understanding people, directly and indirectly, working towards selecting the new technologies or dealing with such

systems' UX goals. We offer insights based on our empirical studies that can be used to analyse and evaluate the lesson learned in co-designing for future scenarios. We co-created scenarios, personas, and AH as design methods to answer several questions: How co-designing with stakeholders can help bring UX and work to the center of automation? How to improve work engagement through automation design? How can using personas lead to optimal task allocation between workers and autonomous future technologies?

3.1 Field observations and workshops proposal

Case studies are considered adequate and necessary research tasks in social sciences [15]. We collected qualitative data from our case studies and used that as an efficient method to develop theories inductively. The case studies' primary focus area understood the overall approaches for selecting and introducing the new automated technologies and developing new digital solutions in complex companies. We analyse the case studies using qualitative data collected through two trial observations, interviews, and the Attrakdiff survey on active trials. However, we do not aim to discuss the field observation data in this paper.

Our observations on the trials and the shortfalls seen regarding the use, usability, and UX of these tested technologies helped us suggest the airport user-centered design tools and methods for introducing new automated systems. We suggested that using co-design workshops with employees can help the organisations select an efficient automated system for emergent future in a complex organisation - a system with better user engagement and interaction than their trials. This suggestion then triggered two co-design workshops with 14 researchers, industry decision-makers, and employees. We suggested the following framework for their future scenarios in the workshops.

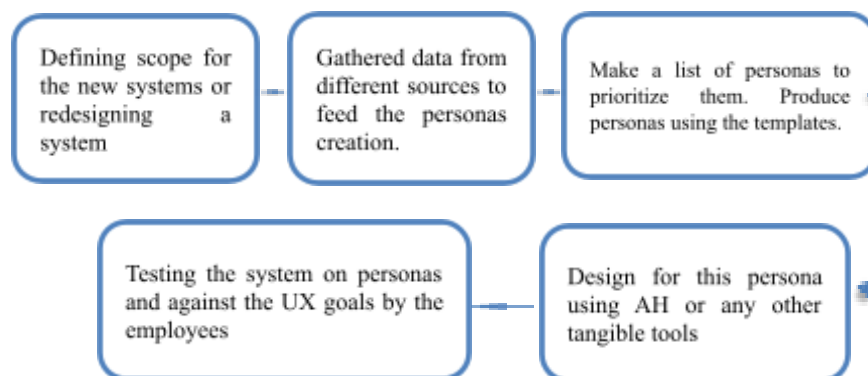


Fig. 1. – Co-designing workshop for new automated systems

3.2 Workshops 1 and 2

After running several observations on the aforementioned trials, we noticed that the airport selects their future technologies mainly by running trials and observing how the trials proceed. However, customer and employee satisfaction and UX in the trials were not easily assessed and articulated.

We invited a number of employees from operational, tactical, and strategic organisational layers to be involved in a co-design workshop with two university design researchers. The workshop used design tools to facilitate knowledge exchange and understanding between diverse stakeholders. Participants were selected from different departments: automation manager and two of his team members, procurement manager, HR talent recruiter, an employee from service design, a baggage data scientist, an operational data scientist, a business change/IT infrastructure specialist, a business analyst and personal assistant with background and interest in design and one intern with a computing background.

Table 1. The number of participants from academia and industry at each workshop.

Workshop	Design researchers	Design Practitioners			Total
		Decision maker	Worker	Consultant	
1	2	4	7	1	14
2	2	4	4	1	11

The design researchers introduced topics and design techniques such as focused groups, brainstorming and mind mapping, trending technologies and innovation, automation requirements, design thinking, and the concept framework to workshop 1. Participants engaged in prototyping system concepts for autonomous systems needed in their departments. They considered the customer demands and value proposition of such systems in their design. All participants had enough experience with autonomous technologies and leading Industry 4.0 implementation either by researching the field or working in the case company implementing industry 4.0 new digital technologies.

The first workshop aimed to map and identify current trends and developments within the aviation industry and construct a corpus of ideas about future technologies for their smart workplace. Each group produced two future technologies concepts in the first round after refining the categories into the future's short and concrete experiences. We had a sharing and voting session to discuss and converge on the most appealing alternative future scenarios. From a list of suggested scenarios (automated helpers, autonomous tugs, context-aware guest invites system, baggage tracing, and the smart asset management.), the participant selected two:

- Autonomous Tug and Pushback Taxi (ATPT)
- Automated Asset Management and Maintenance (AAMM)

In workshop 2 we used customer job (part of value proposition canvas), persona's template, AI/UX goals [28] and AI guidelines [2], sketching, and AH [9] to prototype the short-listed future scenarios voted in the workshop 1. Researchers fulfilled a facilitator role supporting participants unfamiliar with the design tools and were active designers while engaging in creative tasks. In the last stage of workshop 2, each group, walkthrough their concept [51] using their low fidelity prototype and received feedback from other colleagues and decision-makers on how likely the idea is feasible. Finally, group members evaluated their design with UX goal templates [2, 28].

3.3 Workshop outcome

Scenario 1- Autonomous Tug and Pushback Taxi (ATPT)

Participants in team one were asked to assess the current pains and future gains of airplanes' Tug and Pushback Taxies services. The result presented in the customer job tabular format is part of the new proposed system's value proposition.

Table 2. Participant result on the Customer jobs, users, pains, and gains on scenario 1

Main Users	Pain	Gains
NATS (National Air Traffic Services)	Not sustainable	Less Human involvement in the dangerous job (Ground handlers)
Ground handlers	Resource dependency	Engine CO2 reduction
Airlines	Increased CO2 footprint	Noise reduction
Pilots	Increased noise pollution	Optimise routes (currently Pilots selects the routes)
AOM/APOC	Increased fuel waste	Fuel safe, customer service
Data scientist	Increased traffic congestion	
	Time-consuming	

Participants considered different stakeholders and end-users from a pilot, ground handlers, NATS (National Air Traffic Services)- ground movement, APOC (Airport Operation Centre), AOM (Airport Operation Management) to Data Scientist, TUG manufacturer, and Autonomous Technologies. After prioritising the stakeholders, they have selected three stakeholders based on their importance and influence for creating assumption-based personas. They used their own or other participants' experience and data from the field and workplace in their discussion to select the final stakeholders for creating personas. Figure 2 is an example of a ground handler persona designed by the scenario1 participants.

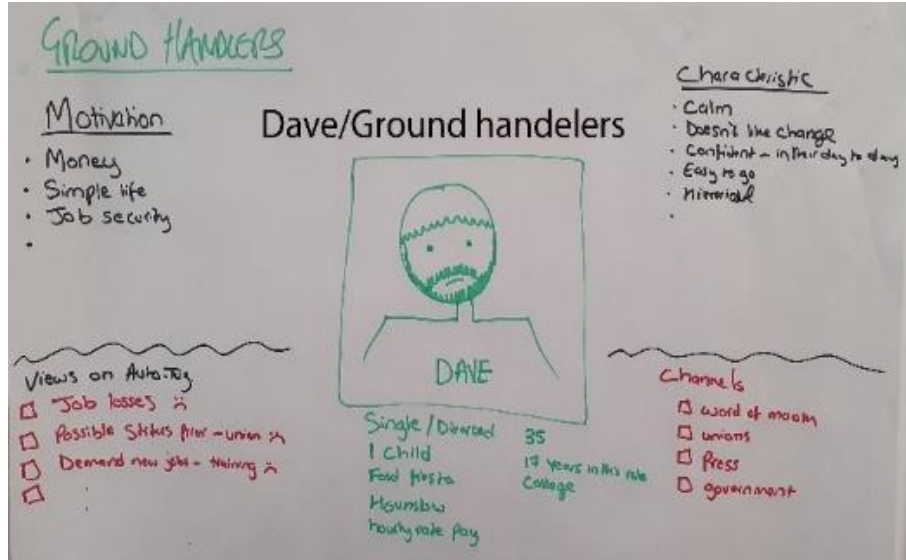


Fig. 2. Scenario 1-ATPT- Ground handler persona



Fig. 3. Scenario 1-ATPT- Abstraction Hierarchies

Scenario 1- Prototype

The team proposes self-driving taxis navigated by AI between the allocated lanes. For refueling, the taxis communicate this to the central system and can automatically find their nest. Currently, airports use tugs that are partially automated and need to work with human counterparts. These systems are not initially fully autonomous and may need to be orchestrated with a central brain initially, and after enough learning for AI, they can become autonomous. The tug can take or get to a certain point. Therefore, the possibility of plane crashing is unlikely to happen. There are many difficult crossings over taxiways, and the team believed AI could help find the route more efficiently. Other participants are concerned that this system should either have a process to monitor the system or a human overseer who monitors the system. The team believed ATPT systems would have a different level of automation at the start (e.g., AI advising and the human approve it) till both can build sufficient trust, then the human role will gradually step back, and AI takes over. The team has concerns when an accident happens, who should blame, human or the system. After going through the AH result (Figure 3) and testing the UX goals with their personas, the team concluded that ATPT should be more flexible. Currently, this system may not be economically beneficial for the airport.

Scenario 2- Asset Management and Maintenance (AAMM) .

Like the other team, this group used their field data and experience to assess the customer pains in the current system and proposed future gains. Then they have listed the stakeholders and the potential end-users.

Table 3. Participant result on the Customer jobs, users, pains, and gains on scenario 2

Main Users	Pain	Gains
Managers Ground handlers Analysts Other relevant departments	Lack of information on the status of equipment Poor quality of information Health and Safety concerns in current systems Insufficient deployment (e.g., staff needed) Required number of unnecessary visits (including Repeat Inspection or Preventative Maintenance)	Real-time information using RFIDs More reliable, valid information using analytics Safer workplace Less human is required Reduce the number of unnecessary trips

Participants prioritised a list of the stakeholders who may work with AAMM, from the systems resource allocator, planning manager, remote engineer to Jarvis (AI engine) and the apprentice engineer. Their role and impact were covered in the prototype of the system. Figure 4 is a sample of Jarvis AI Engineer persona created by the team.

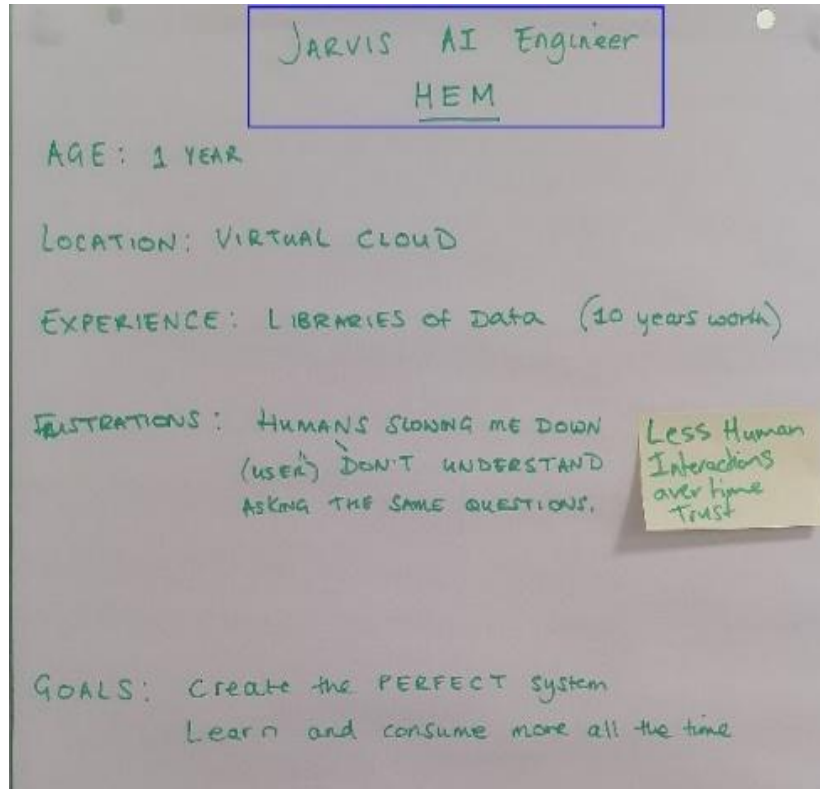


Fig. 4. Scenario 2- AAMM - AI Engineer persona

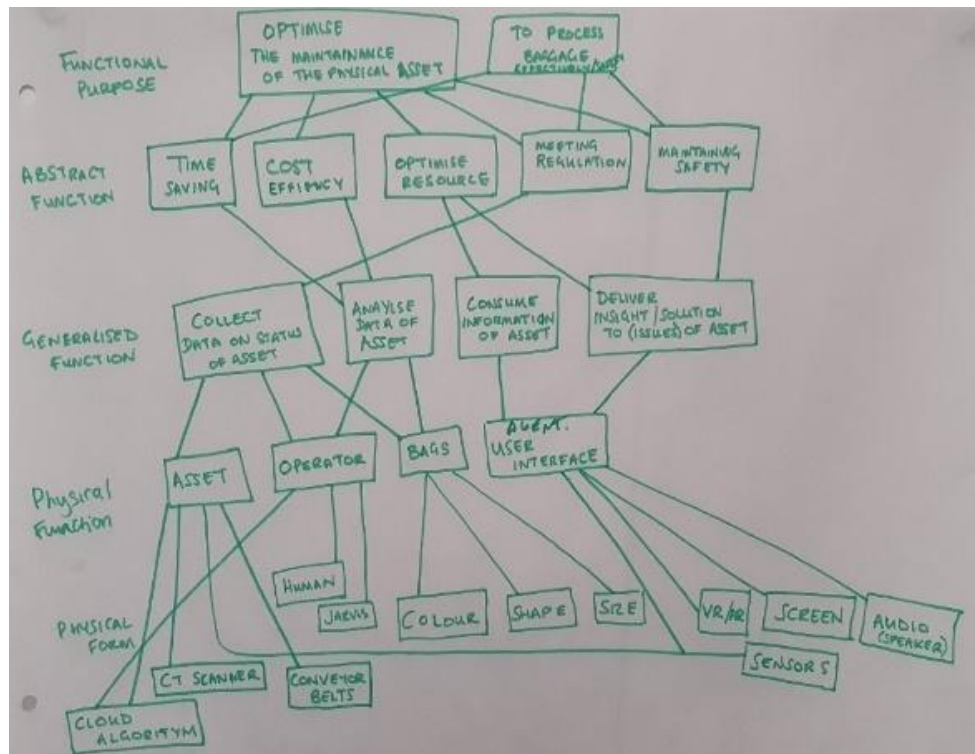


Fig. 5. Scenario 2- AAMM - Abstraction Hierarchies

Scenario 2- Prototype

Team 2 used **Figure 5** for the AAMM concept walkthrough. This system works with sensors, IoT, standard digital twin working with AI engineer (Jarvis) digging the data for more insight continuously. Jarvis interface works with voice commands and has visualised results to share with the human counterpart. A twin system works with video analytics and AI engineer with remote access while using mixed reality and sensors. The system has an interface with a screen divided into one for the real videos (streaming the baggage systems) and one for the digital twin. Jarvis (AI Engineer) can send information about the failure to the resource allocator. Apprentice can learn more efficiently using the digital twin and apply changes to the twin instead of watching the simulation. Therefore, learning through mixed reality can enable new workers to learn step by step without damaging the existing system.

As well as having an AI engineer helping the engineering by using augmented reality, AAMM also has a real remote engineer (or a team of engineers) on the airport side. When the problem is identified, the remote engineer can step in and sort the issue. This system can increase the efficient use of high valued experienced engineers and specialists. The workforce can change to a much more significant percentage of less experienced human counterparts and a core of remote engineers' experienced engineers.

4 What we learned

This case study's main contribution is helping the airport co-design automation scenarios incorporating workers' UX and their work. The primary learning insights are based on the interactions and outputs from the field observations, focus group, brainstorming session, co-design workshops transcripts, and researchers' notes. We also considered the group discussions during both concept walkthroughs to find valuable insights. We coded all the data and clustered our findings into the initial headings resulting from the literature review. We added one new heading based on the most alluded insight about the workshop settings. We removed the repeated comments and summarised our findings into three themes: operational environment, organisational environment, and co-designing workshop settings. The section closes with a short recommendation for co-designing for sustainable work in future automation.

4.1 Operational Environment

Humanistic elements of interactive systems.

Analysis of the functions' allocation is necessary to identify the optimal distribution of functions and tasks between a partly autonomous system and the user [12]. The role of AI and systems and the task allocation were clear for the participants in their design. Both teams show interest in providing physical support of human workers by robots or machines as an essential aspect of the new technologies, precisely, for tasks with a range of unpleasant, repetitive, too exhausting, or unsafe nature [26, 50].

For an effective, successful, and safe support of users in physical tasks, robots or machines should interact smoothly and intuitively with their human counterparts [50], and that humans should be adequately trained [20]. All participants agreed that working with the machine could increase their performance in both scenarios. They trust in the power of the machine and AI in a busy complex environment like an airport. In both scenarios, they wanted the machine to be replaced for more unpleasant, dangerous jobs or jobs with a task allocation nature, which can quickly turn to algorithms and codes. They all want to improve the interaction for all users and change the systems to communicate with more visualisation, gestural interface, and voice commands.

Sense of control: Although a sense of control for higher valued jobs was important for participants in both scenarios, lower-skilled jobs were believed to be more efficient by machines making the decisions. In ATPT scenario, it was a concern that human decision-makers should have more power to approve the system's decisions to be fully trusted. Currently, systems with these features are used in airports, and this system cannot bring a unique value proposition.

Training and skill development: In scenario 2, one persona was described as an apprentice who was not happy with the airport's old operating system and was keen to implement the modern system. Understanding the new generation who are “Technology Savvy” is a critical well-being factor. It is crucial to study resilience and ability to keep roles multi-skilled and avoid de-skilling the workforce by Industry 4.0 in airports. Labour capacity can be doubled by dual-trained staff who are flexible and multi-tasked [16]. The London-based airport can use digital technologies as a more accessible, appealing, flexible, and faster training platform (e.g. eUniversity, virtual classrooms, augmented reality, digital twins, mobile learning). This was an exciting finding for the workshop's decision-maker as it can take some burden from human trainers and leave that to digital twins with mixed reality for job training.

Agile working: Cross-functional “purpose teams” in the same fashion as semi-autonomous working teams are described at the core of socio-technical theory [47]. Experts from entirely different disciplines –engineering, marketing, and logistics – can work together in smaller units. This is not just about collaboration within teams, but it will transform the entire organisational unit. Scenario 2 suggested the “Scaled Agile Framework” in various divisions to achieve better performance using Jarvis, “AI engineer” to make the best use of remote engineers in various airport sites. Creating agile organisations and eliminating hierarchical and functional boundaries will bring new demands on human resource management, development paths to leadership, and project career tracks.

The value of information.

The value of information is now more recognised in collaborations between humans and machines, given the machine's high power in decision-making in highly automated systems. For instance, informing users about the decision in scenario 1 and asking for professional human approval can significantly increase the trust in the system [20]. However, other studies show that the number of information items or tasks users receives in an automated process should be personalised and up to the point of their desire/tolerance [13].

Not enough functions allocated to a user will lead to underload and boredom and thus decreased performance. Too many allocated functions will lead to cognitive, perceptual, or motoric overload and increase negative emotions (e.g., stress, anxiety) [45] and user's error [4, 49]. Meanwhile, users can cope with emotions after spending some time with autonomous technology and developing some routines [12]. Considering the design progress, the more time participants spent in the design and engaging themselves with the design, the more interest they developed in using the airport system.

Providing an abundance of information and transparency is a critical necessity in interactive technologies. Trust, transparency, and acceptance of losing control (i.e., shared authority between the user and system) can improve the user's interaction by revealing ambiguous feelings toward the automation. Other psychological factors under study include worries about practical challenges and security of the technology (e.g., hacking a system) and reliability of the process itself (e.g., flat mobile phone

battery for systems that rely on applications). Users may lose their trust in the decision-making of an automated system when other humans who will not follow the same process are involved and can impact the outcome. For example, if self-driving tugs use a specific system, than drivers who do not use the system and won't follow the same rules [13]. Both groups considered this not only for the psychological factors discussed but also the culture of associating AI systems with high risks in the airports as the system takes control from the human counterpart.

Blame Culture: Another critical situation is when responsibilities are shared between users and the system. Ability to identify responsible parties related to a bad outcome (i.e. user error versus system failure) can impact users' performance [33]. Team members of scenario 1 have concerns that having a blame culture in the aviation sector will be an issue for task allocation in their proposed system. They want to ensure the tug manufacturer takes responsibility when the blame goes on the system.

Data volume and its influences on technology acceptance: Due to the high volume of data in an airport, all personas and participants show interest and need to use AI systems to increase their efficiency. However, in our field observation, we noticed that low-skilled jobs have a different perspective and are scared of losing their jobs regarding AI systems. (e.g., the Receptionist serving her notice period left the airport for a less technologically advanced firm after she had a new robot colleague. She believed in the first-mover airport; her job would die quicker than other institutions). Considering we did not have any representatives from the low-skilled groups, the result may be biased.

Trust and safety consideration: Controllable designed interface and work environment, and feeling safe while using new technologies are among other factors that can increase users' performance. Scenario 1 can impact human life, and trusting a system like this reminded the participants of the Air France accident due to autopilot failure in 2009 [7]. Aviation insurance policies are considered in the designs as a limit by our team 1. AI is associated with risk as it takes control from human for insurance in aviation.

Involving users in the design process.

It will be of great importance to ensure that the future's autonomous systems will be designed to fit into everyday life. Motivating the users to engage with the new technologies is still a challenge due to a lack of understanding of the end-users individual experience and interaction with such technologies. Users can have different roles or backgrounds that can affect their discovery, collaboration, and learning of the interactive systems [30]. At the end of this workshop, through increased awareness of the work domain, most participants understood how a future automation prototype could better fit their work environment. They have agreed that there is a relation between modes of discovery, design improvements, interaction, and socio-spatial aspects. At the end of the session, one of the participants with a senior manager position referred to co-designing and WDA methods to select and design future automation scenarios and prototypes for the airport.

Automation level to match workers' needs: Using automation in interactive systems requires considering potential changes in human activity and the new coordination demands on the human operators. These experiences depend highly on the automation type and level [37] and the extent to which the developer has allowed the machine to make decisions. In both scenarios, participants required different decision-making levels, which also reflected well in the system prototype.

4.2 Organisational Environment

Industry 4.0 success in any organisation will be the result of countless trials and restructurings. The London-based airport is not an exception to this. One trial case study failed as the existing surveyors did not find a proper location in the terminal for an automated kiosk. The innovation team believed such jobs had never existed in their structure before.

The restructuring of the workforces can include several aspects such as employment and worker qualifications, change in the future trends for occupations, qualification types and levels, and new organisational structures, which are at the core of traditional principles of socio-technical systems design [47]. All participants believed that these changes are undergoing in the airport. Moreover, scenario 2 shows how the proposed system can change the workforce into a more significant percentage of less experienced human counterparts and a core of experienced remote engineers. Therefore, while scenario 2 considered using more low-skilled staff and experts more efficiently, scenario 1 may reduce low-skilled jobs.

Creating persona for the AI engine and the autonomous systems in both scenarios shows that machines may be considered an important part of the organisational structure in future structures. Despite this, machine counterparts are important assets for future organisations and significantly impact the system's performance. Creating personas for AI in scenario 2 is a must in the airport's domain (as AI systems are associated with a risk level) and helps understand machines' motivation and goals to work easier with humans. They believed AI behaves differently in various domains. For example, the same robot in one airport trial will have different behaviour in a supermarket domain.

Co-designing for sustainable work in future automation.

In both scenarios, there was a concern that there would be a change in using new systems to use expert and low-skilled workers. Frey and Osborne's study estimated that 47% of US jobs are at risk [17], mainly low-skilled jobs. Similar to the result of scenario one for cutting jobs among ground handlers by replacing ATAP. From a societal perspective, the rise in automation means replacing workers with robots and machines across a vast range of airports, from drivers to ground handlers or expert engineers to NAT workers. Decision-makers in the workshops felt responsible for redesigning the business models considering the principles and requirements of Industry 4.0 while bringing new systems into this sector. To discover the proper training and disruptive R&D investments, organisations must rethink their strategies

[32]. They are also responsible for “Social Sustainability” (i.e. for employees) as part of their Cooperate Social Responsibility. This implies that organisations need to adapt their culture, prepare their employees for the changes in their job descriptions, and set up training for relevant skills to avoid human resource replacements or, eventually, job cuts for the current employees.

The future automation design process should determine the content and format of information to be shared with users to create an experience of certainty and trust.

4.3 Co-designing workshop settings

We noticed that using such workshops for better employees’ engagement in the emergent future system design or even selecting the trials is beneficial for complex organisations. For a better result in the ideation process, providing a context, scenario, and better facilitation is required. Previous studies cover how the ideation process can be more comfortable and quicker for the participants [21, 39]. We observed that selecting the right design tool can provide a better reflection of the participants’ knowledge. For example, participants found AH complicated to use without the design researchers’ help. Adding more tangible elements [39], such as pre-structured cards and easy-to-use collaborative tools, can always be beneficial.

Moreover, there is a need to use data-driven design tools for the co-design workshops for future scenarios. Accessibility to relevant data in the templates, collaborative platforms or any other forms can provide better context and understanding for the participants before using these tools. Preparing the environment to ideate is another important factor; participants should sufficiently understand the scenario, products, and the future system’s domain and environment. In these workshops, the participants were employees from various departments and familiar with the work domain. However, we initially prepared them with brainstorming, group discussion, etc. They were also feeding each other with the relevant data; for example, the innovation team and the HR employee actively responded to the question raised by other employees. The whole process provided them with an exemplary scenario to generate and manage their ideas. Otherwise, we must provide sufficient (internal/external) data for the context and persona creation. In line with the environment preparation and facilitator’s instructions, planning for a scenario in advance for every co-design workshop for future systems is essential. This can help the participant access context and a road map to look forward and share more relevant information.

5 Conclusion

5.1 Limitations

We had planned to interview the practitioner and the decision-makers on our workshop’s validity in their natural environment for the second phase of this study, which was cancelled due to the COVID-19 outbreak and the sudden impact on

aviation human resource availability and layoffs. We also believed a link between the AH physical layers (involves contextual analysis) to structure data collection for creating personas. We observed that participants' engagement with AH as a design tool was not straightforward. Using examples and more tangible tools can help participants to use AH more efficiently. Further research aims to explore AH's possibility and its relation to personas as a design tool.

5.2 Conclusion

The presented case study's main aim is to explore and illustrate how a London-based airport uses participatory design, interaction design, and WDA methods to make decisions on future autonomous Industry 4.0 systems that incorporate workers' experiences. The paper presented two scenarios, ATPT and AAMM, in an airport domain based on customer profiles, personas, scenarios, AH, and a rough prototype to achieve this goal. The eight nominated AI/UX goals [28] were tested in the context of these two scenarios. After the workshop, it was highlighted in participants' responses that using this method helps them better understand workers and the aviation sector's needs and perspectives for selecting the new autonomous systems, which was not part of their practices before. This method gave participants a platform for sharing the experience and understanding of these systems. Remarkably, creating an AI engine persona shows how future workers are willing to share responsibilities in decision-making with their machine counterparts. Participants see their future workplace supported by more technology, more mobility, remote working, using digital twins, drones, wearables, and mixed reality (virtual reality and augmented reality). They believe new technologies will benefit from gestural interaction, more screens, and wearable, voice commanded systems that can communicate easily, remotely, and real-time access information via sensors. They believe these systems can increase the interaction and well-being of the workplaces.

This case study proves that designing with a socio-technical lens at the intersection of UX and Automation can work in real-world industrial applications. Participatory design activities were used as a powerful tool for envisioning future automation technologies and workers' well-being. The fact that UX researchers and airport employees jointly did WDA in these two scenarios shows how workers may be the best consultant to draw the line between automation and human activities for their well-being.

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